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EFFECT OF SELECTED PIGS GENOTYPES ON THE TEXTURE OF MEAT PRODUCTS

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The performed investigations comprised six groups of fatteners differing with regard to their genotype in which the maternal element was PLW x PL breed sows mated with Duroc, Hampshire, Hampshire x Duroc, Pietrain and Pietrain x Hampshire breed boars. Purebred PLW x PLW fatteners were used as the control group. The following parameters were determined: slaughter value, meat quality, technological efficiency of smoked loin and cooked ham as well as the texture and sensory characteristics of these products.

In comparison with the crossbreds with the Pietrain and Hampshire breeds, the authors found higher yields of smoked loin which was manufactured from the meat of the purebred fatteners and crosses with the Duroc breed. More favourable tenderness determined using sensory, penetrometric and texture methods was determined in smoked loins derived from the fatteners upgraded with the Duroc breed in comparison with crossbreds obtained from matings with the Pietrain breed (respectively: hardness – about 47 N and 85 N; shear force – about 22 and 67 N).

Sensory tenderness and penetrometric traits of cooked ham obtained from the muscles of the examined genetic groups were similar and highly desirable (mean hardness – 47.6 N, shear force – 18.9 N) and these characters were undoubtedly influenced by massaging.

INTRODUCTION

It is generally accepted that pork meat quality depends both on genetic as well as on environmental (in particular – nutrition) factors. The most important genetic factor influencing the nutritive and technological quality of pork is the breed or the crossing model from which the given fattener derives. According to Kortz [quote after Migdał *et al*., 2004], there are two distinct meanings of the notion "quality" in the technology and science of commodities, namely – technological quality and consumption quality. Majority of traits of pork quality associated with its technological quality is predetermined genetically.

Investigations indicate that the meatiness increase of fatteners, in some cases, is connected with the deterioration of the quality traits of meat intended for culinary and processing purposes [Borzuta, 1998; Migdał *et al*., 2004]. It seems particularly important to determine the impact of unfavourable meat qualities of various genotypes of commercial fatteners on the technological efficiency of various products in the course of their processing as well as their interrelations with quality, especially with the texture of final products.

The investigations carried out so far appear to indicate that the reduced processing yield of meat is connected with a poor water holding capacity and a fairly considerable variations in the level of loss drip from the meat tissue of fatteners derived from various genotypes [Krzęcio *et al*., 2004; Migdał *et al*., 2004].

The aim of the presented investigations was to verify in practice technological yield of products manufactured from the meat of fatteners derived from different mating models and to determine their texture and sensory traits.

MATERIAL AND METHODS

The investigations comprised six groups of fatteners differing with respect to their genetic type and kept in identical environmental and nutritional conditions on a farm in the region of Wielkopolska. The experimental material included ham and loin muscles (30 samples of each) cut out from chilled swine half-carcasses of the following hybrids: control group – purebred fatteners of Polish Large White PLW x PLW (K); experimental groups: sows of Polish Large White x Polish Landrace (PLW x PL) breeds mated with boars of Duroc (D), Hampshire (H), Hampshire x Duroc (HD), Pietrain (P) and Pietrain x Hampshire (PH) breeds.

Warm, hanging left half-carcasses were used to carry out measurements of meatiness using a CGM optic-needle apparatus and back fat thickness in 5 places on the carcass: over the shoulder, on the back (over the last rib) as well as on the ham in points KI, KII and KIII [Borzuta, 1998].

Using a pH-meter equipped in a combined electrode Radiometer PHM 80, pH measurements were carried out 45 minutes (pH_{45}) and 24 hours (pH_{24}) after stunning in the *longissimus dorsi* muscle at the height of the last rib. Electrical conductivity was determined at the same place with an MT-03 conductometer 24 h after slaughter.

Moreover, the following parameters were determined in the lumbar part of the LD muscle: water content (by the drier

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method), fat content (by Soxhlet method according to PN--73/A-8211) and the value of loss drip from the muscle tissue (samples weighing approximately 100 g were placed in foil bags and left at the temperature of 4°C; after 48 h, the size of the drip was calculated from the difference in weight).

Smoked raw loin was manufactured from the thoracic part of the LD muscle, from the section between the 6th and 11th vertebra, whereas the cooked ham was made from the *quadriceps femoris* muscle (ham was not analysed in groups P and PH).

Cleaned, lean muscles were cured in brine with the following composition: sodium chloride – 6%, sodium nitrite – 0.055%, sugar – 1.1%, sodium ascorbinate – 0.04%, water – 92.805% [Mathes, 1992; Tyszkiewicz & Olkiewicz, 1991].

Methods employed to manufacture cooked ham and smoked, raw loin. Ham muscles were injected brine intramuscularly using 4 to 5 injections employing for this purpose a hand injector type 501 of the Mifam Company and the amount of the injected brine was 15% of the weight of the element. Next, ham muscles were placed in appropriate containers and soaked in brine at the ratio of 2:1 in which they were left for 48 h maintaining the temperature at the level of 4-6°C. After curing, the muscles were placed in a vacuum massage machine type MP1B, COBR and massaged for 240 min (effective massaging time) with the addition of 30% brine [Lachowicz *et al*., 1997; Tyszkiewicz & Olkiewicz, 1991]. Muscles formed in this way were placed in elastic nets and smoked with hot smoke at the temperature of 60-70°C for the period of 2 h until they were light brown. Ham thermal treatment was carried out in water until the inside temperature reached 68-70°C.

Sections of the LD muscle were placed in containers and soaked with brine at the ratio of 2:1. The curing process lasted 2 days and the temperature was maintained at 4-6°C. Dripped and dried muscles were smoked using warm smoke at the temperature of 25°C. The smoking lasted approximately 15 h until the muscles were light brown with a shade of gold [Technological Instruction, 1986].

In order to characterise technological efficiency and quality of the finished products, the authors: (1) determined increments of muscle weights during the curing process in% to the weight of the fresh muscle; (2) determined the concentration of sodium chloride – using Mohr method in accordance with the Polish Standard [PN-73A-82112]; (3) carried out the sensory evaluation of the manufactured meat articles by determining: the colour (desirability, uniformity), juiciness, tenderness and palatability. The assessment was conducted by a trained, 5-person panel of judges using a 5 point scale [Baryłko-Pikielna, 1975; Tilgner, 1957]; (4) determined the colour with the assistance of the Minolta Chroma Meters CR-300 apparatus, establishing L^*a^* b^* parameters in the HunterLab system [Oziembłowski & Grashorn 1997]; (5) established texture parameters of the obtained meat products using, for this purpose, an Instron 1140 apparatus [Chrystall *et al*., 1994].

Samples for texture measurements were cut along the meat fibres as a rectangular parallelepipeds with sides 1 cm x 1 cm x 4 cm. Measurements of texture parameters were done perpendicular to the meat fibres, calculated (in%) the yield of the final product in relation to the fresh raw material.

The obtained results were elaborated statistically using a single factor orthogonal analysis of variance. The comparison of mean values between genetic groups was performed with the assistance of the Duncan and test NIR (as a test and an accompanying method). In addition, simple correlation coefficients were calculated between selected parameters of fresh meat quality and the parameters of the smoked raw loin [Ruszczyc, 1981; Stanisz, 1998]. The enclosed Table presents mean ($\overline{\mathbf{x}}$) standard deviations (s) as well as the significance of differences between the examined groups of fatteners.

RESULTS AND DISCUSSION

The results of the performed investigations provided information about differences occurring between the examined genetic groups regarding their slaughter value, meat quality and technological efficiency of the examined meat products. The obtained results corroborated the positive influence of three- and four-breed crossings on the results of the dressing performance of the examined fatteners, which was also reported by other researchers [Rak *et al*., 1993; Buczyński *et al*., 1996]. The analysis of the degree of musculature of the assessed crossbreds revealed a significantly higher (by 2 to 6%) meat content in the carcasses of fatteners derived from boars of Hampshire and Pietrain breeds in comparison with the re-

TABLE 1. Characteristics of slaughter value and meat quality fatteners of investigated genetic groups.

Specification	K	D	HD	H	P	PxH	SEM
Hot carcass weight (kg)	75.83	74.74	74.93	73.75	76.21	73.02	3.95
Meat content in carcass (%)	50.55^{A}	52.09^{A}	56.25^{B}	56.28^{B}	54.10^{C}	55.27^{B}	3.93
Mean value of 5 backfat thickness measure (mm) Muscles LD:	28.48^{A}	25.43^{B}	25.45^{B}	21.94^{C}	24.20^{B}	24.44^{B}	4.39
pH_1	6.52^{A}	6.48^{A}	6.35^{C}	6.22^{D}	6.23^{D}	6.28^{D}	0.29
pH_{24}	5.74^{A}	5.69^{A}	5.57^{B}	5.50^{B}	5.66^{A}	5.67^{A}	0.19
EC_{24h}	4.85^{A}	4.83^{A}	5.14^{B}	6.35^{C}	6.29^{C}	6.58^{C}	1.35
Drip losses (%)	3.58^{A}	3.96^{B}	5.27^{C}	6.25^{D}	7.30^{E}	7.52^{E}	0.88
Fat content (%)	3.36^{A}	4.79^{B}	3.25^{A}	3.45^{A}	2.25^{C}	2.10^{C}	0.76
Water content (%)	72.66^{A}	71.06^{B}	73.34^{C}	73.68^{C}	74.43^{C}	74.13^{C}	0.75

A,B,C,D,E – significant at $p \leq 0.01$

maining groups. Worse carcass muscle development was observed in fatteners upgraded with the Duroc breed (group D – 52.09%) and in the control group (group K – 50.66%).

The degree of carcass fattening was characterised by measurements of the back fat thickness taken from 5 points of the carcass. The highest content of back fat was determined in carcasses from the control group in which it was by 3 to 7 mm thicker (mean from 5 measurements).

The performed analysis of fresh meat in the examined genetic groups failed to determine watery ($pH_{45}\leq5.8$) and dark DFD meat (Table 1). In addition, this meat was characterised by relatively low electrical conductivity ranging from 4.83 to 6.58 mS, *i.e.* typical for normal meat [Kauffman *et al*., 1993; Strzelecki *et al*., 1995]. Nevertheless, mean pH_{45} values were recorded significantly lower in the groups upgraded with the Hampshire and Pietrain breed boars (groups H, P and P x H). In addition, in comparison with the remaining genotypes, electrical conductivity in muscles of these groups were higher. From among the examined genetic groups, muscles of the fatteners upgraded with the Pietrain breed (groups P and PH) were characterized by lower content of intramuscular fat. Moreover, in these genotypes, as well as in group H, the authors found higher natural drip from the muscle tissue. Koćwin-Podsiadła *et al*. [2004] reported a considerable variability of the natural drip from muscles in the case of experiments carried out on fatteners characterized by a similar crossing model. Moreover, in the same article, the authors drew attention to a very undesirable phenomenon which poses a problem for both consumers and meat processing industry, namely in carcasses in which no typical meat defects are observed, high frequency of the occurrence of the elevated (over 6%) level of meat juice drip is recorded.

The performed investigations, first and foremost, made it possible to establish to what extent interspecific crossing can influence meat technological efficiency during its processing. During the curing process (Table 2), brine was absorbed most readily by the meat from the carcasses of the control group (group K – 9.89%) when compared with the meat from the remaining groups. In comparison with the control group, meat of fatteners from groups H (by 3.20%) and D (by 2.77%) showed a particularly low efficiency of this process. Przybylski *et al*. [1998] reported low values of the RTN index in the case of meat derived from crossbreds from an identical group

TABLE 2. Technological of parameters of finished products.

Groups	Smoked loin			Cooking ham
	Increase of weight in curing	Yield (%)	Content of NaCl (%)	Yield (%)
K	9.89^A	90.32^A	3.34^A	94.66^A
D	7.12^B	90.62^A	2.66^B	93.95^A
HD	8.87^C	90.07^A	3.45^A	90.85^B
H	6.69^D	87.85^B	3.25^C	86.94^C
P	8.65^C	84.96^C	3.52^A	
PH	8.28^C	81.83^D	3.50^A	
SEM	1.44	2.41	0.48	5.35

A,B,C,D – significant at $p\leq0.01$

of H. In the case of the meat of hybrids upgraded with the Duroc breed, the obtained smaller weight gains during the curing process could have been caused by quite considerable fattening of the muscle tissue. That is why the process of brine diffusion into the muscle tissue of these crossbreds took longer. These observations are corroborated by experiments carried out by Szota & Niedosug [1990]. These researchers analysed sodium chloride degradation in tissues and found from 2.14 to 2.70 times less NaCl in the fat tissue than in lean muscles. Na^+ and Cl^- ions appear to play a key role during the curing process because they penetrate through the semi-permeable membranes of muscle cells. Wood [1966] maintains that the penetration rate of Na^+ and Cl^- ions into the muscle tissue also depends on the water content in meat before the curing process. In this process, meat can only absorb such the amount of salt which can be dissolved in free water occurring in the tissue. In the cured meat from the groups of fatteners characterized by higher water content in comparison with group D, higher NaCl content was determined (respectively: 3.25 and 3.52% and 2.66% NaCl in group D).

Another important experimental factor was technological yield of products obtained from commercial fatteners from different groups. During smoking, numerous physical and chemical transformations and quantitative and qualitative changes take place in meat. It is well known that during smoking, the level of water in the result of the drying of the product decreases which has a strong influence on the efficiency of this process. It was found that the meat of fatteners upgraded with Hampshire and Pietrain breeds was characterised by about 2.5% to 8.5% significantly lower yield of the smoked raw loin in comparison with the meat from the remaining groups (groups K, D and HD). Moreover, cooked hams manufactured from the meat of fatteners of group H were characterised by about 7.7% lower efficiency that hams from the control group. It was further found that cooked hams derived from crossbreds with a 25% upgrade of the Hampshire breed (group HD) were characterized by a greater (by nearly 4%) yield than hams from group H (Table 2). Similarly low indices of technological yield for pigs which were carriers of the RN^- gene (RTN from about 85.4 to about 89.0%) during the process of curing and cooking were reported by other researchers who employed the "Napole" method in their experiments [Naveau *et al*., 1985; Monin & Sellier 1985; Koćwin-Podsiadła *et al*., 1998]. The authors claim that the reduced technological yield as well as undesirable quality traits of this meat was the consequence of the presence of the RN^- gene in the population of the Hampshire breed as well as in the crossbreds upgraded by this breed.

The results of the sensory evaluation and texture parameters of the smoked raw loin and cooked ham are presented in Tables 3 and 4. In comparison with groups P and PH (3.93 and 3.80 points), smoked loin manufactured from the meat of fatteners upgraded with Duroc boars and control group was characterised by more favourable tenderness (4.44 and 4.69 points). The above data were confirmed by penetrometric and share force measurements. A significantly greater hardness estimated penetrometrically was determined in the loin derived from the meat of crossbreds upgraded with the Pietrain and Hampshire breed boars (hardness of group P – 70.17 N,

TABLE 3. Sensory properties (points) and colour parameters and evaluation of raw smoked loin texture of investigated genetic groups.

Traits	K	D	HD	H	P	PxH	SEM
Colour compensation	4.56^{A}	4.56^{A}	4.23^{B}	4.58^{A}	3.99^{C}	3.52^{D}	0.30
Colour desire	4.65^{A}	4.50^{A}	4.24^{B}	4.65^{A}	4.14^{B}	3.61^{C}	0.20
Juiciness	4.37^{A}	4.60^{B}	4.47^{A}	4.56^{B}	3.94^{C}	3.72^{D}	0.21
Tenderness	4.44^{A}	4.69^{B}	4.59^{B}	4.29^{C}	3.93^{D}	3.80^{D}	0.22
Palatability	4.64^{A}	4.04^{B}	4.40^{C}	4.44^{C}	3.79^{D}	3.55^{E}	0.22
L*	44.3^{A}	44.15^{A}	50.15^{B}	49.84^{B}	50.36^{B}	58.16^{C}	3.12
a*	6.45^{A}	6.35^{A}	7.73^{B}	8.95^{C}	9.05^{C}	8.93^{C}	1.03
b*	3.32^{A}	3.50^{A}	5.06^{B}	5.80^{B}	4.94^{B}	7.07^{C}	0.86
Hardness (N)	51.72^{A}	47.19^{A}	44.91^{A}	59.88^{B}	70.17^{C}	85.92^{D}	12.06
Cohesiveness	0.276^{A}	0.317^{B}	0.334^{B}	0.211^{C}	0.252^{A}	0.264^{A}	0.055
Elasticity (mm)	4.70^{AB}	5.31^{A}	4.22^{B}	3.46^{C}	3.93^{C}	4.92^{A}	0.77
Shear force (N)	22.29^{A}	22.33^{A}	29.30^{B}	42.33^{C}	53.40^{D}	67.05^{E}	7.47

A,B,C,D,E – significant at p≤0.01

TABLE 4. Sensory properties (points) and colour parameters and evaluation cooked ham texture of investigated genetic groups.

Traits	K	D	HD	H	SEM
Colour compensation	4.15^{B}	4.27^{A}	4.17^{B}	4.15^{B}	0.30
Desirability	4.45^{A}	4.48^{A}	4.31^{B}	4.39^{B}	0.23
Juiciness	4.71^{A}	4.45^{B}	4.24^{C}	4.45^{B}	0.26
Tenderness	4.83^{A}	4.62^{B}	4.61^{B}	4.68^{B}	0.21
Palatability	4.77^{A}	4.09^{B}	4.44^{C}	4.57^{D}	0.17
L*	69.59^{A}	65.59^{B}	68.52^{A}	69.57^{A}	1.92
a*	8.89^{A}	10.87^{B}	9.54^{A}	8.89^{A}	1.15
b*	6.90	6.87	7.15	6.91	0.58
Hardness (N)	48. 05	43.96	49.85	48.63	10.76
Cohesiveness	0.249^{a}	0.284^{b}	0.240^{a}	0.240^{a}	0.065
Elasticity (mm)	5.58^{a}	6.61^{b}	5.60^{a}	5.17^{a}	1.32
Shear force (N)	18.83^{a}	21.76^{b}	17.38^{a}	17.49^{a}	5.15

a,b – significant at p≤0.05; A,B,C,D – significant at p≤0.01

PH – 85.92 N and H – 59.88 N) in relation to the remaining groups (K, D and HD – from 44 to 51 N). On the other hand, the shear force in the first group ranged from about 53 to 67 N in comparison with about 22 to 29 N in the remaining groups. Better cohesiveness characterised smoke loins prepared from pigs with share of Duroc breed (group D and HD) and worse the other groups. The worst elasticity was stated in H and P groups. Significantly worse colour uniformity and desirability were determined on the cross section of the smoked, raw loin derived from crossbreds from groups P and PH (respectively, 3.99 and 3.52 points and 4.14 and 3.61 points) in comparison with the remaining groups (about 4.5 points, on average). The above results were corroborated by the measurements of the colour lightness conducted by the apparatus (Table 3).

Cooked ham, in contrast to smoked loin, was manufactured employing a modified technology (muscle injection and massaging). In the course of the massaging process, considerable changes of meat physical properties take place [Tyszkiewicz & Olkiewicz, 1991] and this was probably the main reason why no significant differences were recorded in the ham tenderness between the examined genetic groups (non-significant toughness determined penetrometrically ranged from 43.96 to 49.85 N). Also similar shear force was recorded in groups K, H and HD (from 17.38 to 18.83 N) and slightly higher in group D – 21.76 N. Favourable ham tenderness assessed using a penetrometre and evaluating the texture was achieved in the result of massaging. During this process, tissue structure becomes loosened, fibres get torn and protein solubility increases [Olkiewicz, 1997]. Hams of the assessed groups were characterised on their cross section by uniform (mean – 4.2 points) and desirable (mean – 4.4 points) colour estimated subjectively and confirmed by the assessment of the colour lightness using appropriate devices.

From among the analysed interrelationships (Table 5), significant correlations were determined between sensory tenderness and palatability as well as the shearing force of the smoked loin and intramuscular fat content (respectively, r = 0.352^{xx}, r = 0.420^{xx} and r = -0.463^{xx}).

TABLE 5. Correlation between quality traits of LD muscles and parameters of smoked loin.

Specification	pH_{45}	pH_{24}	Fat (%)
Colour L*	0.142	-0.114	-0.367**
Tenderness (points)	-0.082	0.160	0.352**
Palatability (points)	0.291**	0.003	0.420**
Shear force (N)	0.197*	0.059	-0.463**

* at p≤0.05; ** at p≤0.01

These results corroborate findings obtained by Kirchheim *et al*. [1997]. The authors also found significant correlations between tenderness and fat content in meat (r = 0.45^{xx}) at the level of over 2.5%. Eikelenboom *et al*. [1996] reported that together with the increase of carcass meatiness, the level of intramuscular fat decreased and, therefore, meat sensory tenderness deteriorated. Similar observations were made in this study, especially in groups upgraded with the Pietrain and Hampshire breeds.

CONCLUSIONS

More advantageous technological yield in the production of smoked raw loin was observed in the case of the meat of the fatteners from the control group and from groups upgraded with the Duroc breed (groups K and D) in comparison with the fatteners which were upgraded with the Hampshire and Pietrain boars (groups H, P and PH). In the case of the smoked loin. The difference in yield ranged from 2.5 to 8.5%, while in the case of cooked ham – 7% on average. From the point of view of sensory evaluation, cooked hams and smoked loin obtained from the muscles of control fatteners of white breeds (group K) were clearly more attractive. Products manufactured from the muscles of crossbreds upgraded with the Pietrain and Hampshire breeds (groups P and PH) were assessed significantly lower. The employed sensory, penetrometre and texture methods awarded better tenderness to smoked loins derived from fatteners upgraded with the Duroc breed in comparison with the Pietrain breed (respectively: hardness about 45 N and 85 N, shear force – about 22 N and 67 N). The tenderness of the cooked ham obtained from the muscles of the examined genetic groups assessed using sensory and penetrometric methods was similar (hardness – from about 44 to 49 N; shear force – from about 17 to 22 N) and this was influenced significantly by the technological factors of the applied production process.

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WPŁYW WYBRANYCH GENOTYPÓW ŚWIŃ NA TEKSTURĘ GOTOWEGO PRODUKTU MIĘSNEGO

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Badaniami objęto sześć grup tuczników różniących się genotypem, w których materiał mateczny stanowiły lochy ras PLW x PL kojarzone z knurami rasy duroc, hampshire, hampshire x duroc, pietrain i pietrain x hampshire. Grupę kontrolną stanowiły tuczniki czystorasowe (PLW x PLW). Określono wartość rzeźną, jakość mięsa, wydajność technologiczną polędwicy wędzonej i szynki gotowanej oraz teksturę i cechy sensoryczne tych wyrobów.

Stwierdzono wyższą wydajność polędwicy wędzonej wykonanej z mięsa tuczników czystorasowych i krzyżówek z rasą duroc w porównaniu do mieszańców z rasą pietrain i hampshire. Korzystniejszą kruchością określoną metodą sensoryczną, penetrometryczną i szerometryczną charakteryzowały się polędwice wędzone pochodzące od tuczników z udziałem rasy duroc w porównaniu do krzyżówek z rasą pietrain (odpowiednio: twardość ok. 47 N i 85 N, siła cięcia ok. 22 i 67 N).

Kruchość sensoryczna i cechy pentrometryczne szynki gotowanej otrzymanej z mięśni badanych grup genetycznych były podobne i wysoko pożądane (średnia twardość 47,6 N, siła cięcia 18,9 N), na co określony wpływ wywarło masowanie.